GeReLEO – SMART

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- Technical description of sub-components
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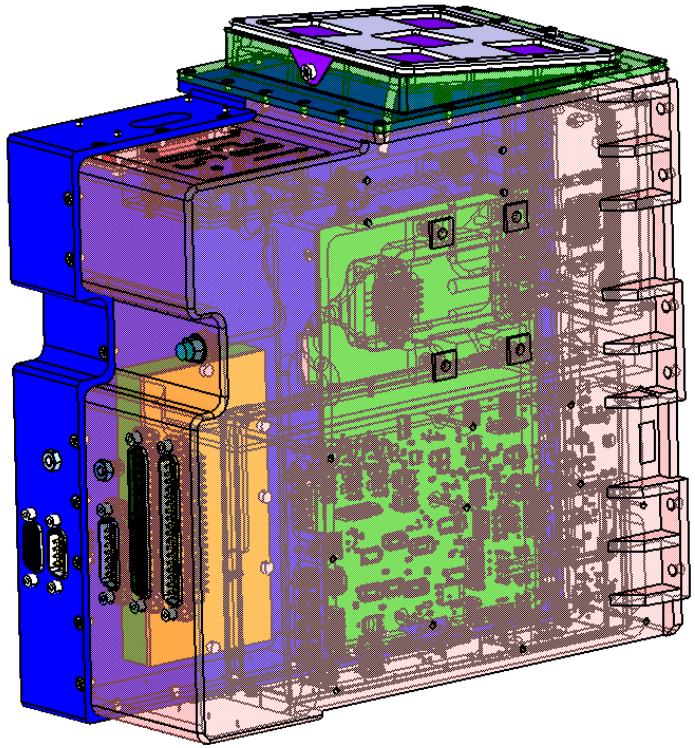
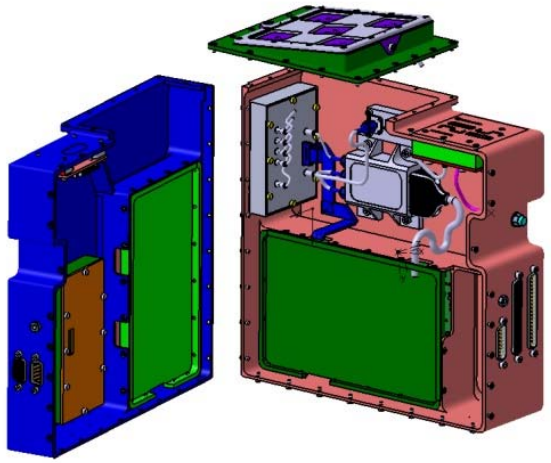


Project Overview

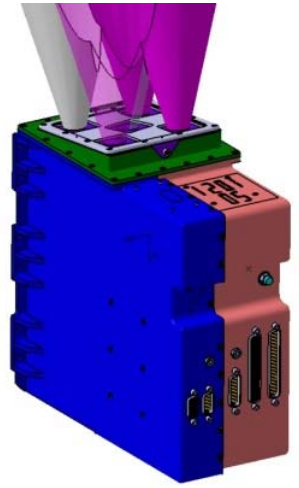
- GeReLEO Concept: Relay Satellite in GEO to establish long term connections between ground station and LEOs
- GeReLEO-SMART: In-Orbit Verification of key technology on H2SAT
  - Multi Layer Patch Antenna with integrated LNA
  - RF MEMS switches to select different antenna groups
  - FPGA to control MEMS switches
- Operating frequency Ka Band (~ 26 GHz)
- Redundant Test Equipment for FPGA and MEMS



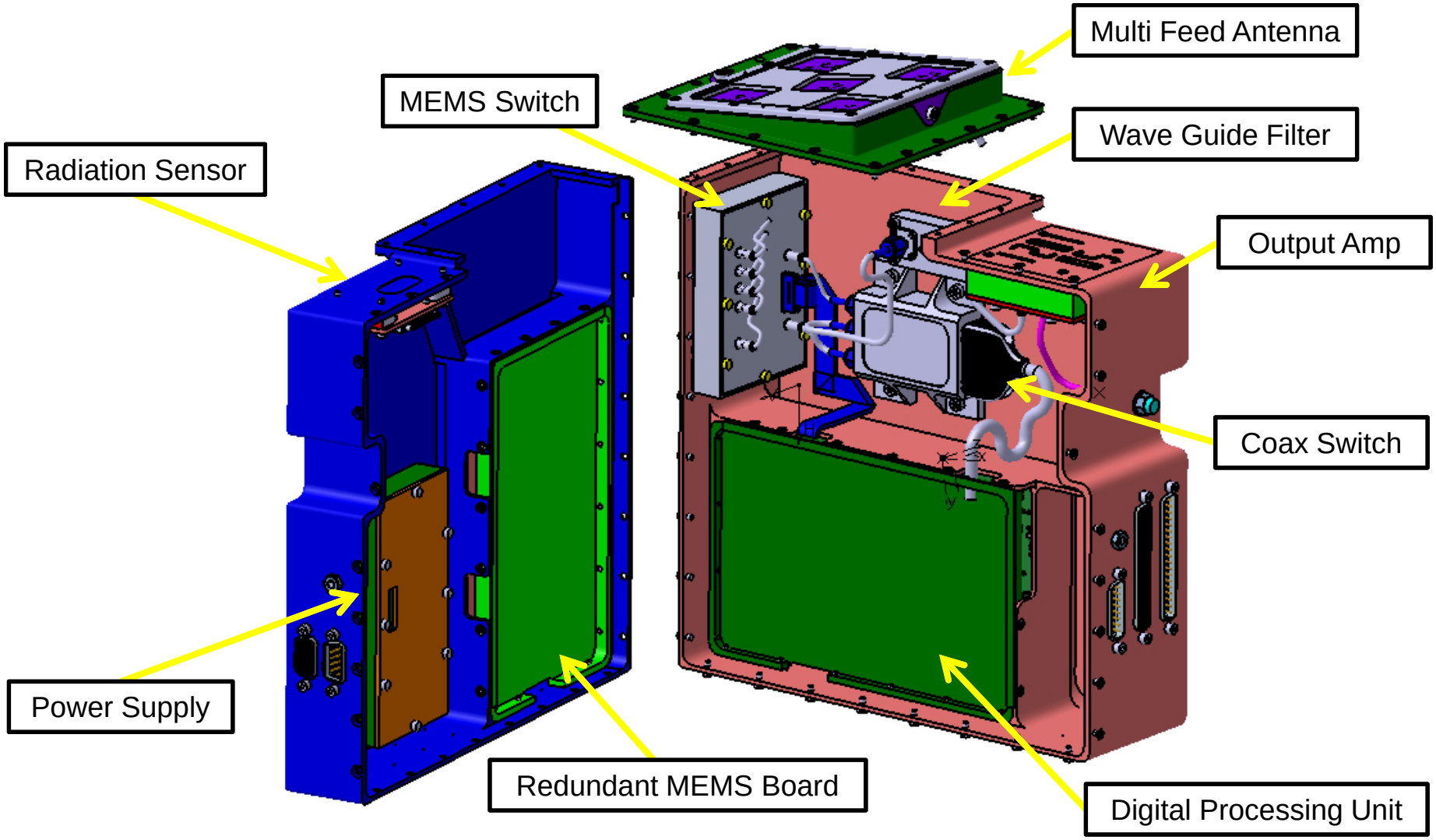
Key objectives of the mission

- In-Orbit qualification and degradation analysis of
  - Multi Layer Antenna based on Teflon substrates with integrated pre-selector and LNA
  - MEMS switches built by Fraunhofer ENAS
  - FPGA for system control, house keeping data and tele command communication
- Experiments and testing will be conducted in periodic time steps in orbit
- Validating and analysis of durability in GEO

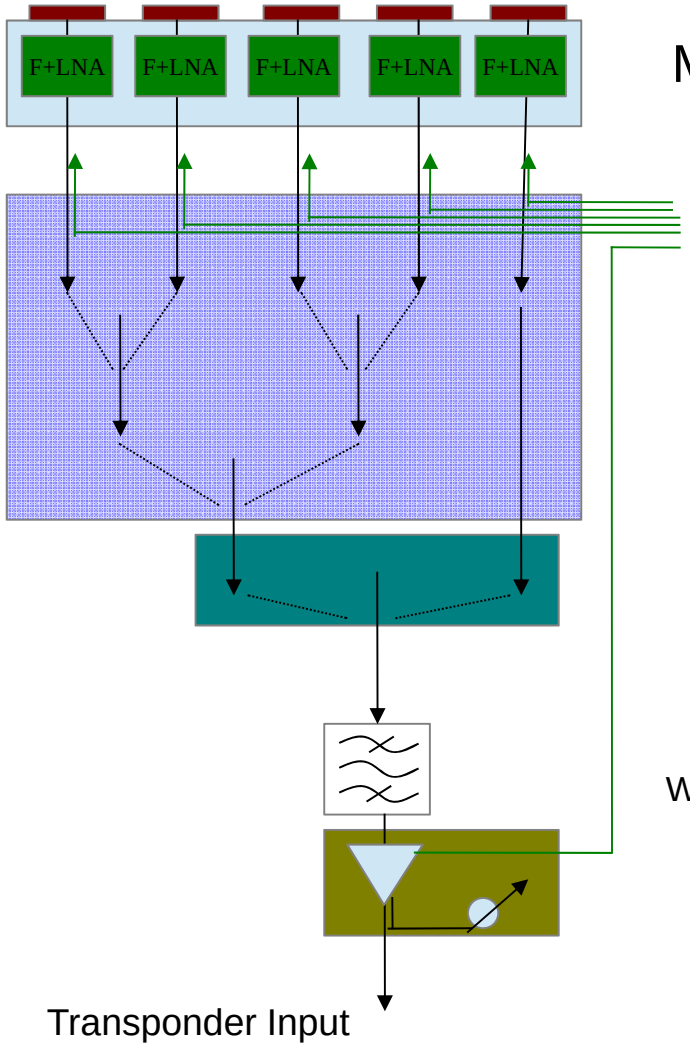
- Communication Experiment
  - Transmitting from Ground Station simulating LEO
  - Receiving signal via H2SAT transponder downlink



Parts of GeReLEO-SMART



RF signal flow



Multi Feed Array
5 Beams

MEMS Board

Coax Switch
SPDT

Filter
Wave Tube BW 36MHz

LNA
+ Power Meter

Micro Switch for GHz frequency range applications

GeReLEO
Creating Access

General:

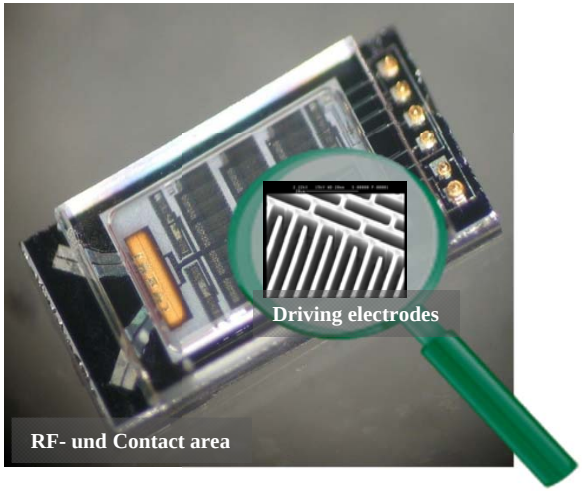
- Electrostatic driving
- Series and shunt switch available
- 3 mm x 1,5 mm x 0,5 mm flip-chip-device
- 4 GHz version and 75 GHz version available

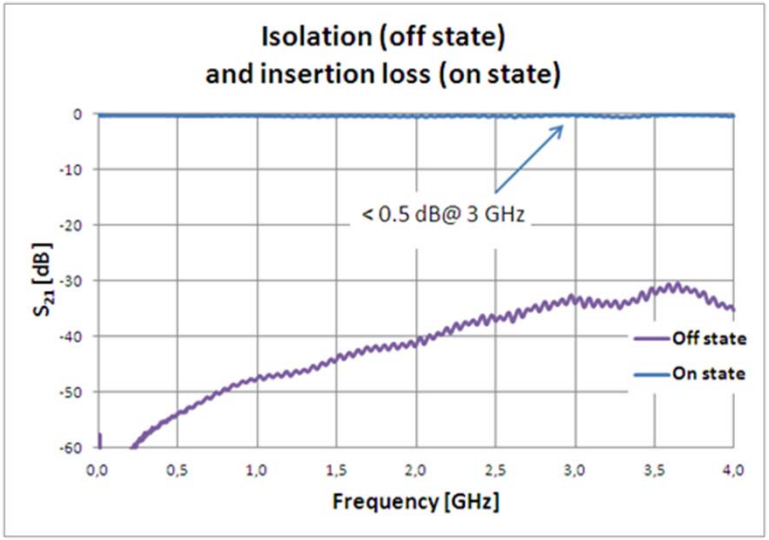
Benefits:

- Very low actuation voltage (<5 V) and short switch on time (<10 µs)
- Lossless actuation
- High contact force (>100 µN) and improved reliability of contact resistance

Applications:

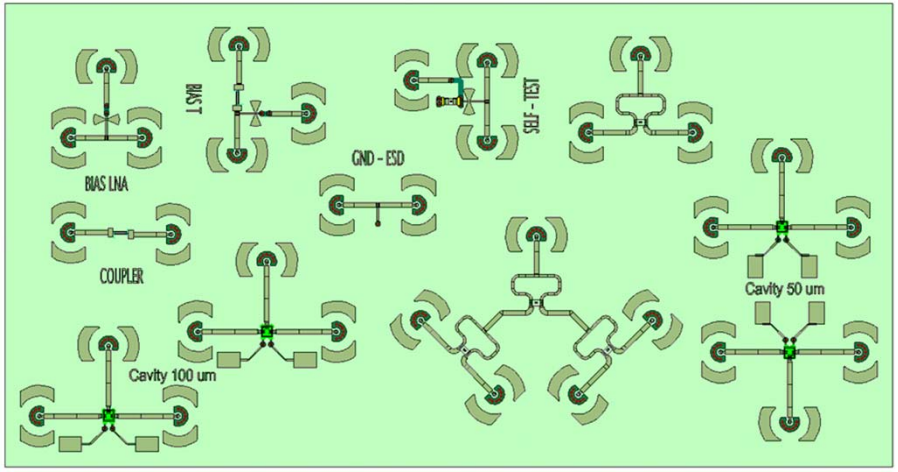
- Adaptive Antenna to improve communication quality in fast changing environment
- Reconfiguration of radio modules for different standards
- Multiplexing switch arrays for test equipment

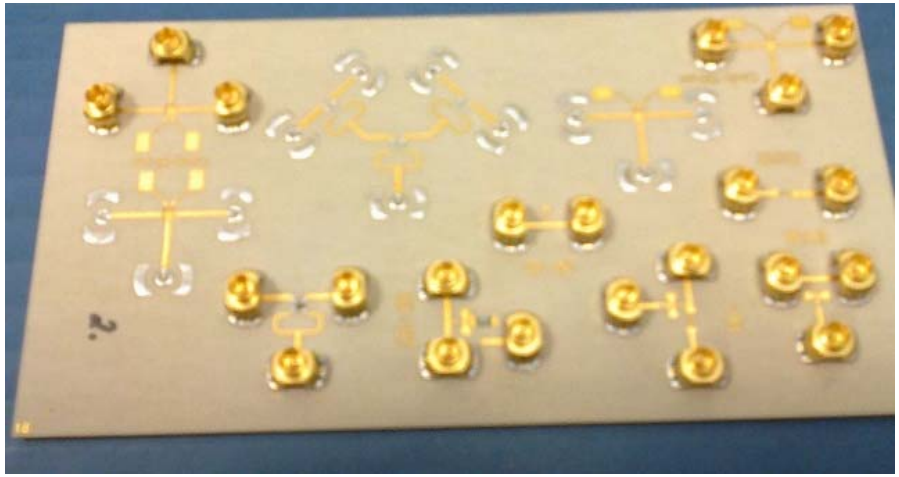




MEMS Switch Board – Component Testing

- MEMS Switch board needs power divider, Bias-T and DC blocking
- Separate test board to check subcomponents

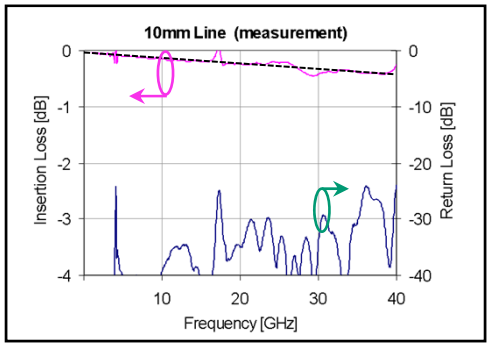




RF building-blocks on Bread Board

GeReLEO
Creating Access

Line 10mm

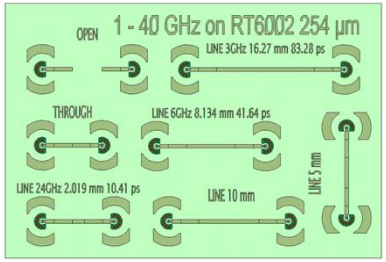


Line Loss

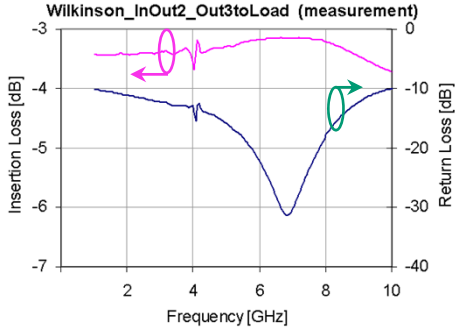
measured
0,25 dB/cm @ 26 GHz

AWR-txline „ideal RO6002“:
0,1 dB/cm @ 26 GHz tanδ 0,0012

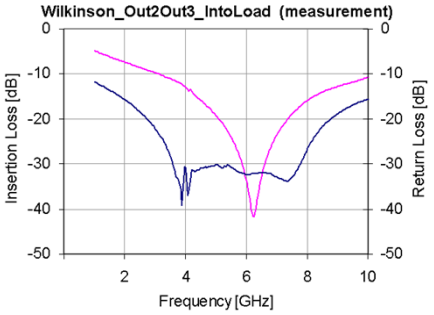
Calibration TRL:
Open, through, Line 1 2 3



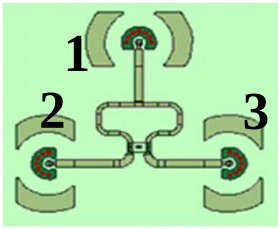
MTB Wilkinson 6 GHz



Loss -3,2 dB



Isolation - 30 dB



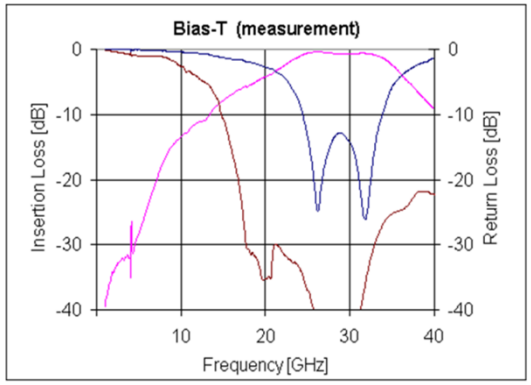
Performance: O.K.

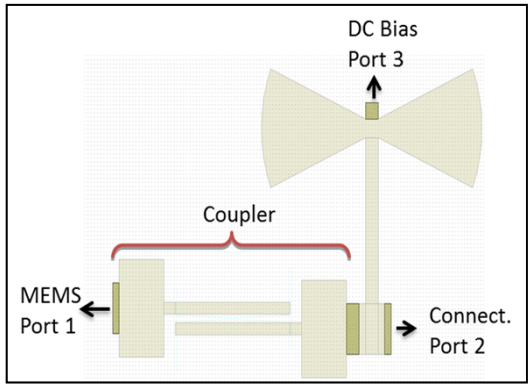
Small frequency shift needed

RF building-blocks on Bread Board

GeReLEO
Creating Access

BIAS - T

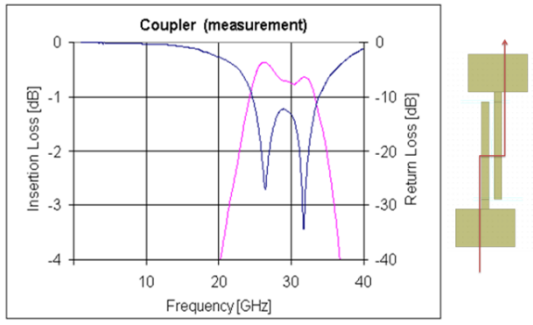




Performance @ 26 GHz O.K.:
I. L. - 0,4 dB
R.L. - 22 dB
Isolation Bias: - 40 dB

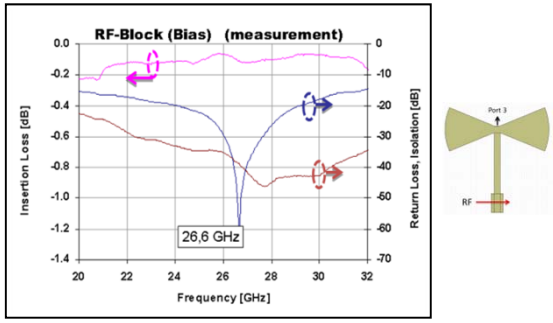
I.L. < -0,6dB @ 25 – 28 GHz
I.L. < -1,0dB @ 24 – 31 GHz
improve manufacturing yield

Coupler



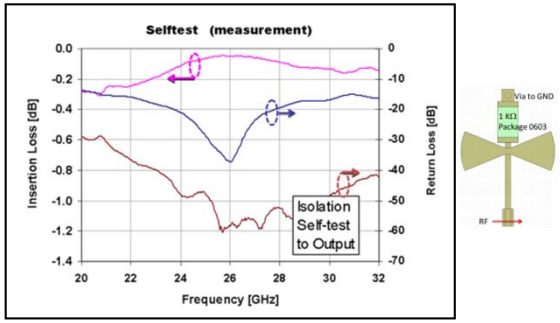
Insertion loss: -0,4 dB

RF - Stop



Insertion loss: - 0,1 dB

Self test



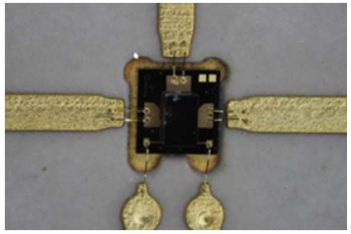
Insertion loss: < - 0,1 dB

Test of single Radant MEMS

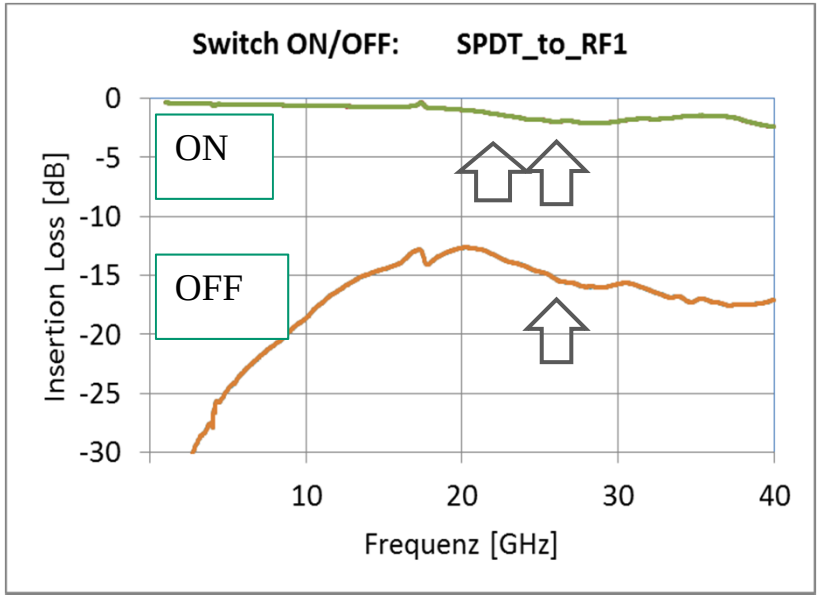
SPDT Radant-MEMS

Port 1

Port 2



50 Ohm

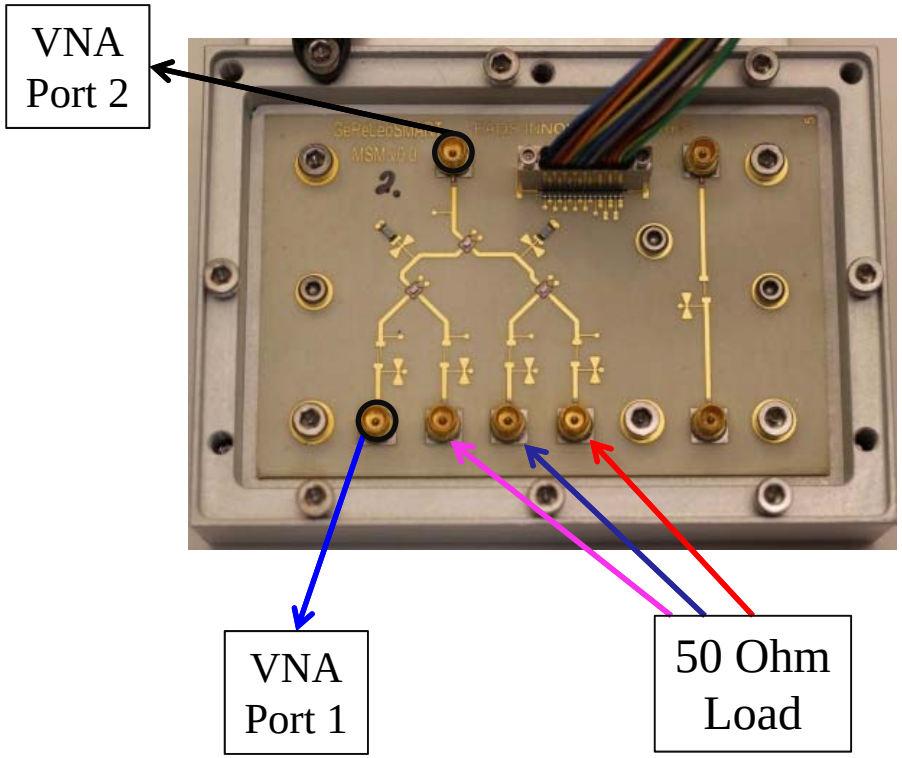


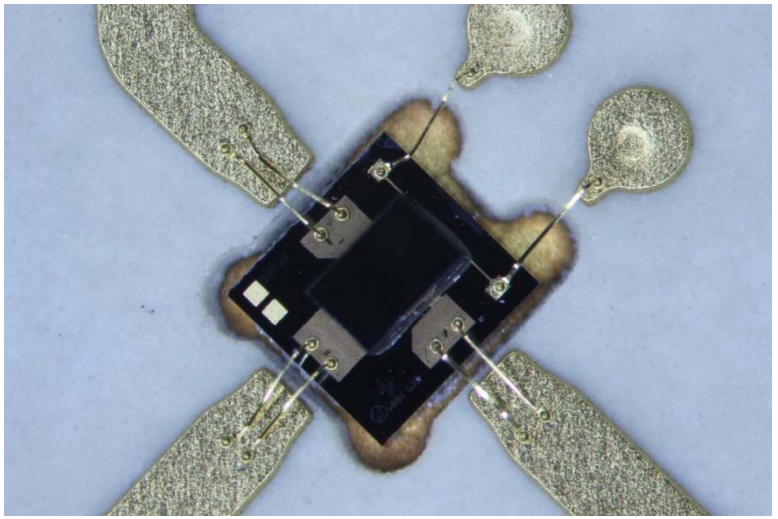
AVT ENAS Nov/Dez 2013

I.L: 2 dB @ 26 GHz 1 dB @ 21 GHz
IS: 15 dB @ 26 GHz 13 dB @ 21GHz

Performance beyond 20 GHz will be further improved by optimisation of AVT

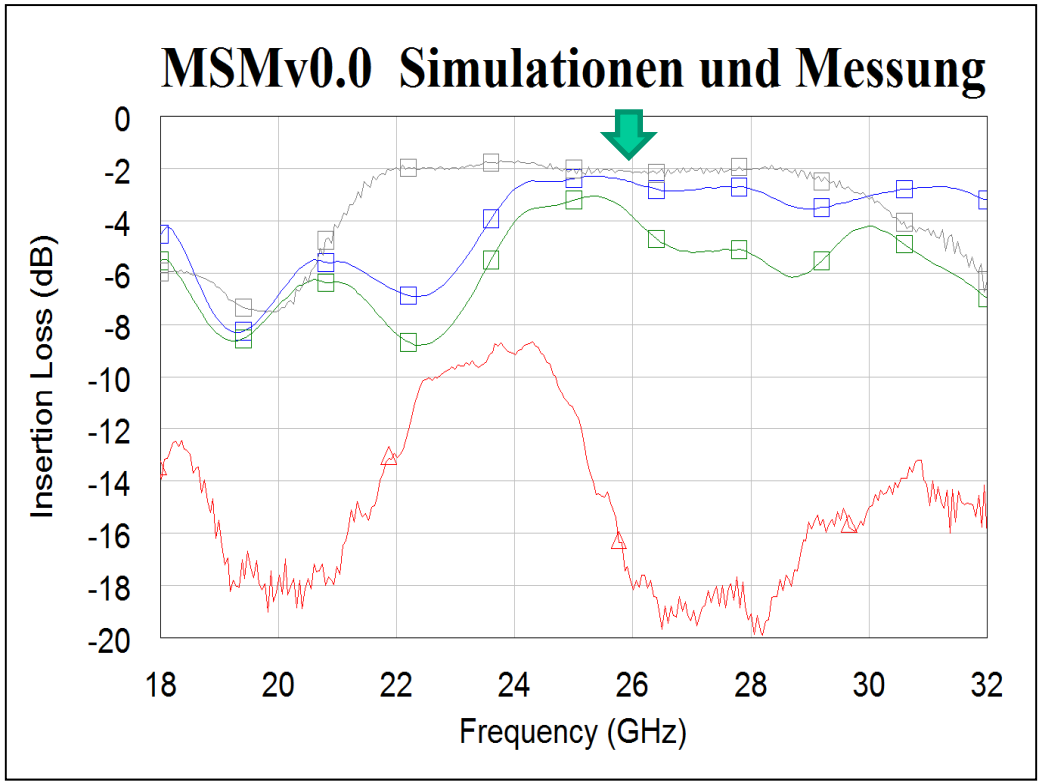
MEMS switch board, Radant MEMS, AVT ENAS





- Testing MEMS with Vector Network Analyser
- Test wiring is causing 4 dB insertion loss @ 26 GHz

Analysis of losses in MEMS board



Simulation without cable & connector

AWR-Model, RO6002-lossy

S-Parameter from measurement bond wire company “Falkenstein”

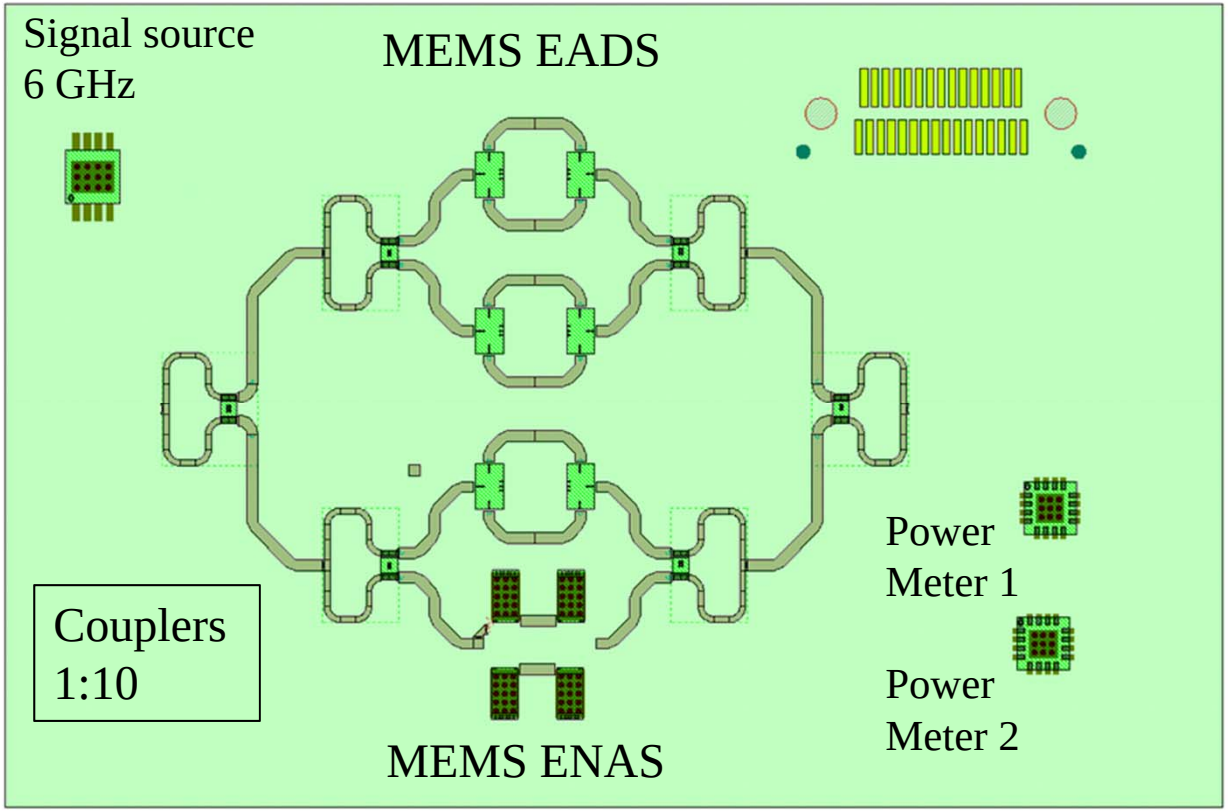
S-Parameter from measurement improved bond wire “ENAS”

Measurement with cable & connector

Measurement MSMv0.0 old bond wire “ENAS”

Simulated losses after optimisation of technique for joining parts
Without cable and connector: 3…4 dB, cable and connector : 7…8 dB

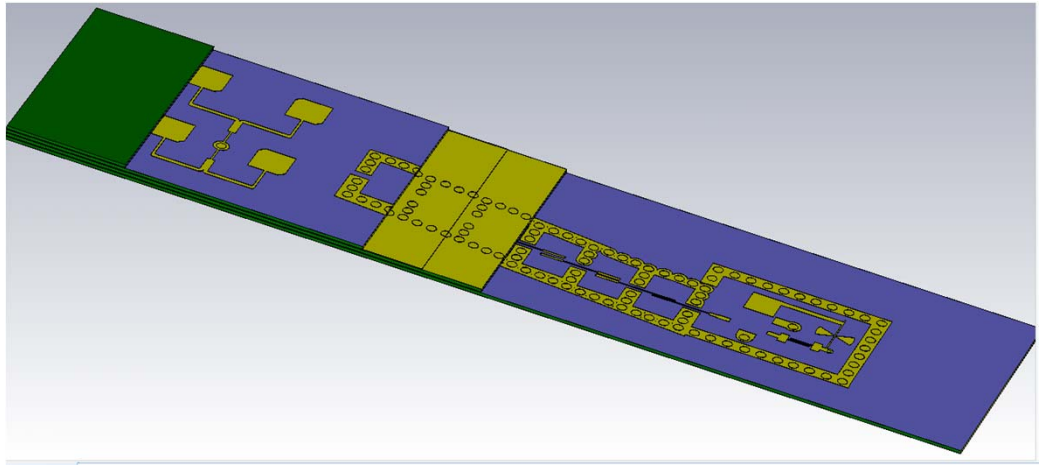
Redundant MEMS Test Board – Preliminary Design

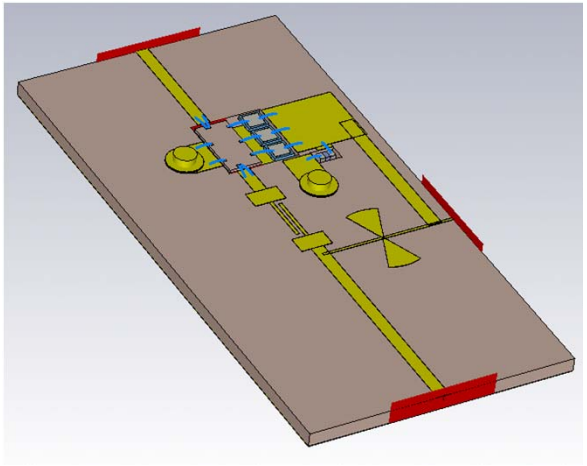


Identical dimensions as MEMS switch board, detailed design still under construction

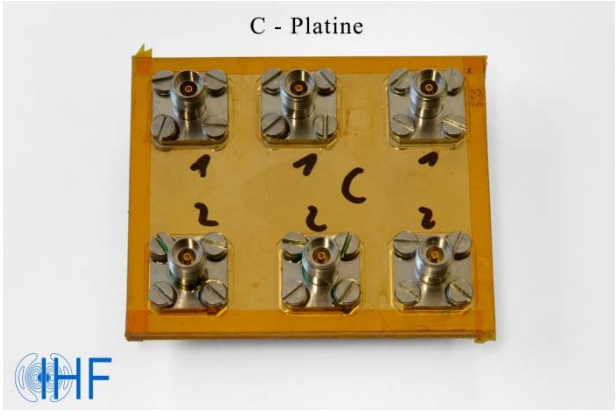
Multi Feed Antenna

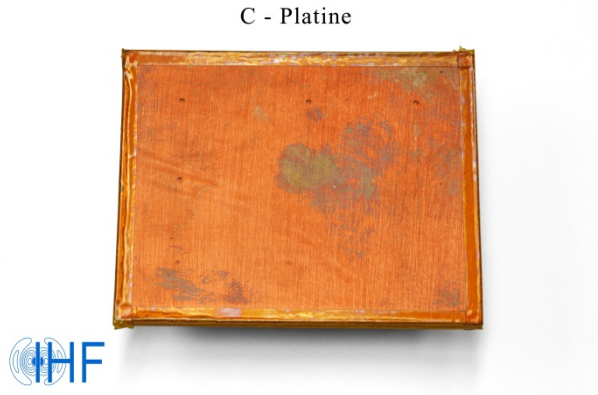
- Two principal substrate materials: Rogers 6002 and TMM3
- 4 layer stack with patch antenna, bonded LNA and pre-selector
- Final choice depending on radiation hardness
- Test fabrication to demonstrate of technique for joining parts
  - Pre-Selector Filter and LNA die bonding Rogers 6002
  - Pre-Selector Filter and LNA die bonding Rogers TMM3
  - 5 groups of 2x2 patch antenna Rogers 6002



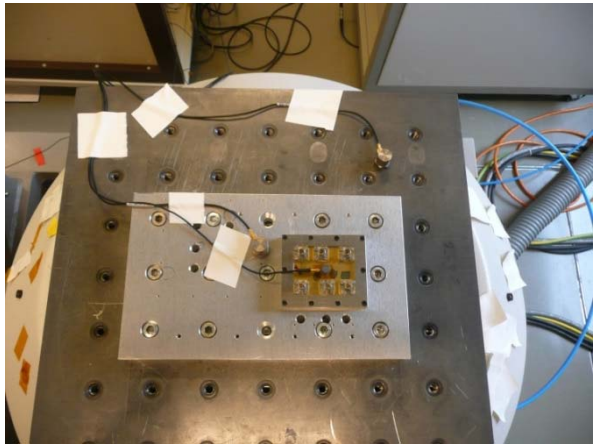


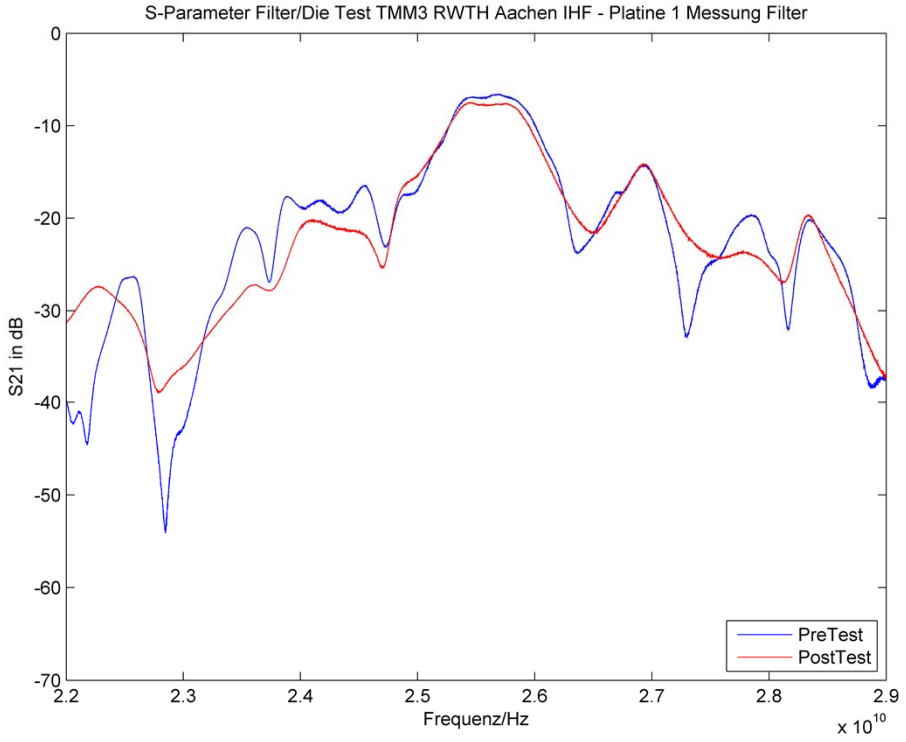
Filter Vibration Test Rogers 6002



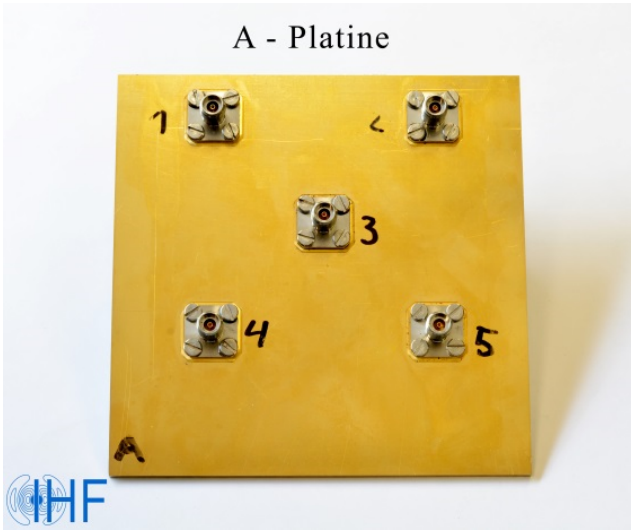


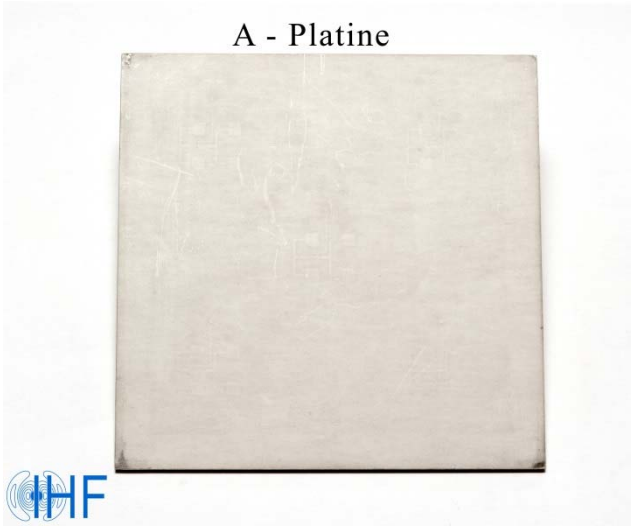
Filter Vibration Test Rogers TMM3

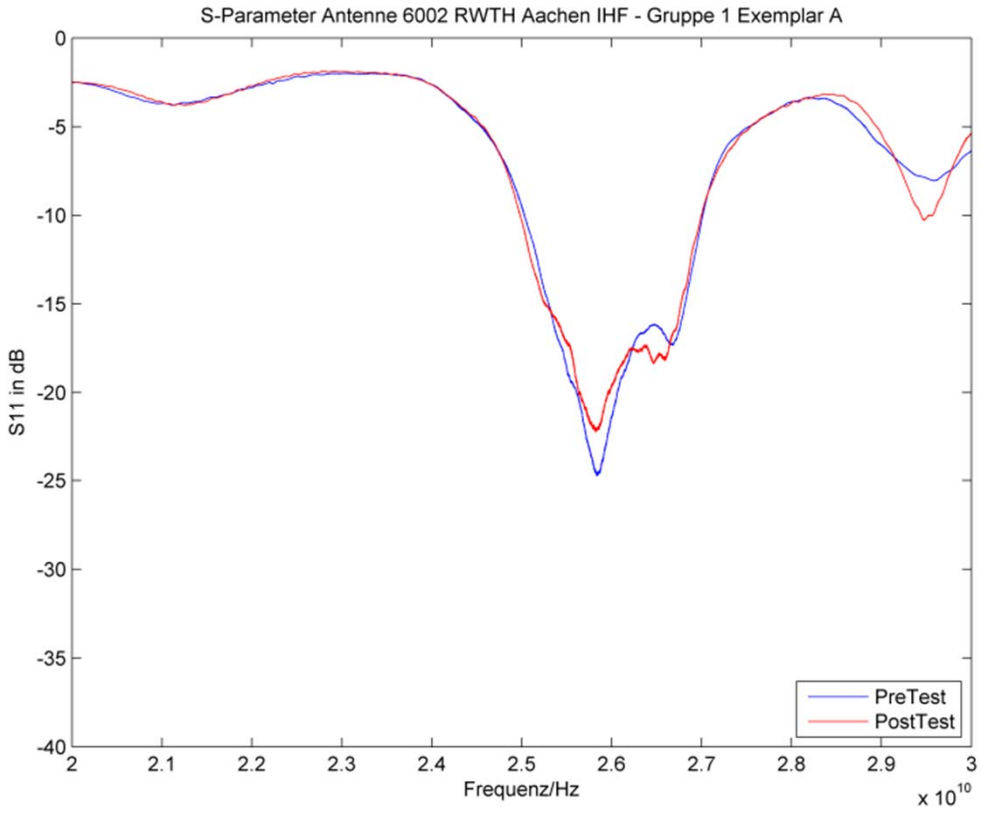




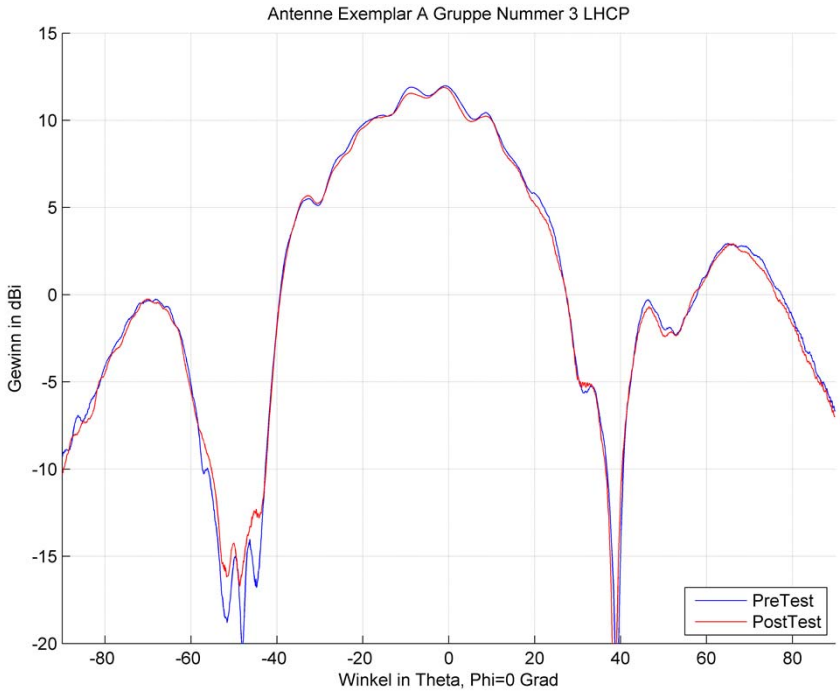
Antenne Vibration Test Rogers 6002

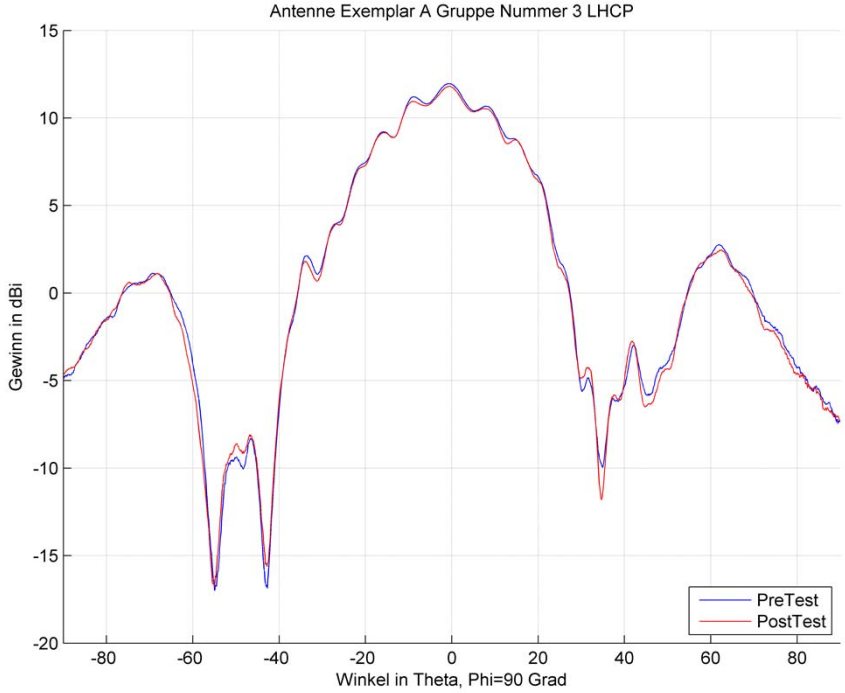






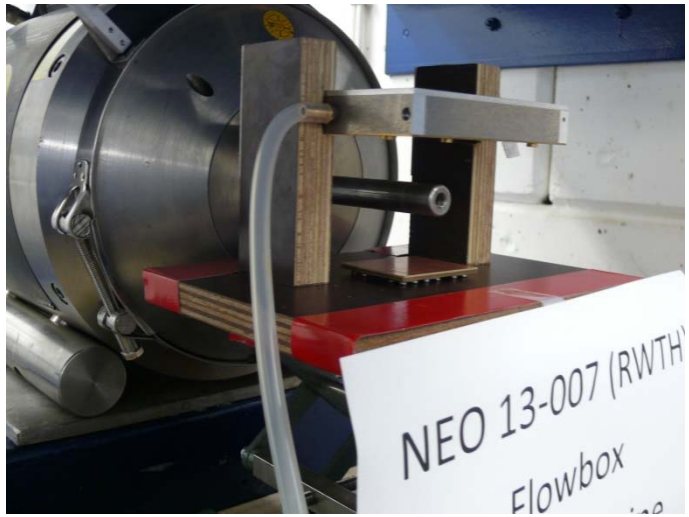
Antenne Vibration Test Rogers 6002





Radiation Test 6002 vs. TMM3

- PTFE was “known” to be not radiation hard
- Antenna substrate is PTFE based → radiation test necessary
- Antenna substrate has almost no shielding,100 MRad in 15 years
- Radiation tests with Cobalt 60 at Fraunhofer INT in Euskirchen
- Step by step radiation dozes augmentation with intermediate tests at RWTH Aachen of S-Parameter and far field radiation
- Preliminary results to be presented at DLR Bauteile-Konferenz in Freiburg



Thank you for your attention